LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Power from the Sun.

IN the very interesting Trueman Wood lecture delivered at the Royal Society of Arts on December 10, Sir Oliver Lodge discussed the utilisation of solar radiation, and recommended, as the best method of effecting this purpose, the promotion of agriculture of every kind. According to Sir Oliver Lodge, the green leaves of trees and vegetables generally are able to absorb and utilise solar energy without much regard for any hampering limit to efficiency such as the second law of thermodynamics, but in saying this he appears to be unaware of the researches of Dr. Horace Brown, who has shown that the actual amount of energy stored is less than 2 per cent. of that which reaches the vegetation.

Now the total amount of solar energy intercepted by the earth is prodigious, being in the aggregate some 200 billion h.p., or, on an average, about 4,000,000 h.p. per square mile of that portion of the earth's surface that is exposed not too obliquely to the sun's rays. Absorption by the clouds and by the atmosphere, though important, is not so great as might be expected, with the result that even in this latitude and in this climate the energy constantly received throughout the hours of daylight exceeds 1000 h.p. per acre.

If, then, some method could only be devised for efficiently converting this energy into a form in which it could be readily applied for motive power and other purposes, the gain and the convenience would be enormous; for, to take a single instance, sufficient energy to run all the machinery in a factory throughout the working day could be collected from an area in many cases not greater than that subtended by the factory's roof.

Now, of course, for reasons which Sir Oliver Lodge fully discussed, it is hopeless to expect to be able to effect anything of this nature with the heat engine, for with this we should scarcely reach the 2 per cent. efficiency nearly attained by vegetation. But is there any need to allow the radiation to turn itself into heat at all? Solar radiation, as is well known, consists of electromagnetic waves in the æther—waves exactly similar in kind to those employed in wireless telegraphy. The only difference is that, whereas the length of the waves used in wireless telegraphy is a matter of hundreds or thousands of metres, the wave-length in the case of solar radiation is only a very minute fraction of a millimetre.

Even with wireless waves the resulting frequency is too great to allow of the electric currents they induce being directly utilised. The telephones and other instruments employed offer too much impedance to allow such currents to pass, while, apart from this, no mechanical device could move with sufficient rapidity to respond to such frequencies. In wireless telegraphy, however, a method has been devised for converting these rapidly alternating or oscillating electric currents into currents which, though pulsating, are unidirectional. This is accomplished by the application of thermionic or crystal rectifiers or non-return valves, which only allow the currents in one direction to pass and suppress altogether the currents in the opposite direction. In this way the comparatively useless high-frequency oscillatory currents are converted into rapidly pulsating unidirectional currents which behave like continuous currents, and will operate telephones and other electromagnetic devices. Moreover, though in wireless telegraphy it is customary to use the currents in a single direction only, and to suppress the inverse currents altogether, there is no difficulty about utilising both currents by turning them into separate circuits with valves set opposite ways. Under such conditions, seeing that the separate valves let through their respective currents with but little loss, the efficiency of the conversion from the radiant energy absorbed to that utilisable in the form of electric current is quite high, probably not less than 50 per cent., and perhaps considerably more.

Is it too rash to suggest the possibility of some analogous method being applicable to convert into utilisable electric currents the electromagnetic waves of which the radiant energy from the sun consists? The method is quite successful with wireless waves having frequencies of millions per second, but can it be applied to the sun's waves, the frequency per second of which is of the order of billions? No doubt the problem is a difficult one, but we live in an age of marvels, and what would have been said of modern wireless methods only a few years ago?

One thing seems certain. The energy in the sun's radiation is there, and there, too, in most abundant quantity. To make use of it, moreover, requires no Maxwellian "demon" such as is necessary to render available the general stock of heat energy at uniform temperature. Nor, again, does what is suggested run counter to any thermodynamical law such as would preclude full advantage being taken of the great efficiency that is rendered possible by the enormous temperature of the sun.

Anyway, the problem of the application of solar radiation to the production of power otherwise than by means of heat engines seems worthy of attention, and is a problem that would appear much more likely to meet with a speedy solution than the difficult and obscure question of the liberation and utilisation of the internal energy of the atom.

A. A. CAMPBELL SWINTON.

66 Victoria Street, London, S.W.1,
December 15.

Heat of Reaction and Gravitational Field.

A SIMPLE relation between the variation of mass in a physical change of state or chemical reaction and the rate of variation with gravitational potential of the corresponding change of total internal energy can be deduced as follows:—Let m_1 and m_2 denote the masses of the initial and final states of the chemical system and Q the heat evolved, say at constant temperature and pressure, and at the gravitational potential Z. Considering the following isothermal cycle:

(*a*) State 1 to state 2 at Z,
(*b*) State 2 at Z to state 2 at $Z+\delta Z$,
(*c*) State 2 to state 1 at $Z+\delta Z$,
(*d*) State 1 at $Z+\delta Z$ to state 1 at Z,

and equating the total change of energy to zero, we get the equation

$$\left(\frac{\partial Q}{\partial Z}\right)_{p,t} = m_1 - m_2.$$

For all ordinary reactions, experiment has shown that $m_1 - m_2$, if not zero, must be very small. It follows, however, from the theory of relativity that if the reaction be exothermic $m_1 > m_2$, whilst if it be endothermic $m_1 < m_2$. Hence in the former case $\frac{\partial Q}{\partial Z}$ is positive, whilst in the latter case it is negative. If we can apply the energy theory to the highly exenergic

© 1919 Nature Publishing Group

radio-active changes, it would follow that the energy given out in such changes must be greater in strong gravitational fields than in weak.

F. G. DONNAN.

University College, London, December 10.

A Helium Series in the Extreme Ultra-Violet.

IN NATURE for November 20 Prof. Lyman reports his observation of a helium line at 1640·1, as well as a weak one at 1215·1, close to the strong one 1216, and refers them to orders 3, 4 in the series $4N\{1/2^2 - 1/m^2\}$. If the correct reading for the strong line is nearer the 1215·1, the whole series $m=4$ . . . 8 is found in his list of ultra-violet lines given in the *Astro. Journ.* (vol. xliii., p. 89, 1916). The following is the list of observed lines with deviations (obs. − calc.) from the calculated values, with N = 109720 :—

Order	Intensity	λ	$d\lambda$
3	strong	1640·2	−0 34
4	10	1215·1	−0·11
5	5	1086·1	+1·08
6	4	1026·0	+0·66
7	3	992·0	−0·37
8	1	972·7	+0·59

The line 1084·9 is closer to the calculated with $d\lambda = -0{\cdot}11$, but its intensity of 2 is not in step with the others. In estimating possible errors, those of standards as well as of observation have to be considered. With uncertainties also of formula, the values of $d\lambda$ do not seem excessive.

W. M. HICKS.

Crowhurst, December 11.

The Constitution of the Elements.

IT will doubtless interest readers of NATURE to know that other elements besides neon (see NATURE for November 27, p. 334) have now been analysed in the positive-ray spectrograph with remarkable results. So far oxygen, methane, carbon monoxide, carbon dioxide, neon, hydrochloric acid, and phosgene have been admitted to the bulb, in which, in addition, there are usually present other hydrocarbons (from wax, etc.) and mercury.

Of the elements involved hydrogen has yet to be investigated; carbon and oxygen appear, to use the terms suggested by Paneth, perfectly "pure"; neon, chlorine, and mercury are unquestionably "mixed." Neon, as has been already pointed out, consists of isotopic elements of atomic weights 20 and 22. The mass-spectra obtained when chlorine is present cannot be treated in detail here, but they appear to prove conclusively that this element consists of at least two isotopes of atomic weights 35 and 37. Their elemental nature is confirmed by lines corresponding to double charges at 17·50 and 18·50, and further supported by lines corresponding to two compounds HCl at 36 and 38, and in the case of phosgene to two compounds COCl at 63 and 65. In each of these pairs the line corresponding to the smaller mass has three or four times the greater intensity.

Mercury, the parabola of which was used as a standard of mass in the earlier experiments, now proves to be a mixture of at least three or four isotopes grouped in the region corresponding to 200. Several, if not all, of these are capable of carrying three, four, five, or even more charges. Accurate values of their atomic weights cannot yet be given.

A fact of the greatest theoretical interest appears to underlie these results, namely, that of more than forty different values of atomic and molecular mass so far measured, all, without a single exception, fall on whole numbers, carbon and oxygen being taken as 12 and 16 exactly, and due allowance being made for multiple charges.

Should this integer relation prove general, it should do much to elucidate the ultimate structure of matter. On the other hand, it seems likely to make a satisfactory distinction between the different atomic and molecular particles which may give rise to the same line on a mass-spectrum a matter of considerable difficulty.

F. W. ASTON.

Cavendish Laboratory, December 6.

The Deflection of Light during a Solar Eclipse.

THE fall of temperature that may occur in the higher strata of the atmosphere during an eclipse is somewhat doubtful, but can scarcely exceed half a degree. An attempt was made to measure it directly during the partial, but nearly total, eclipse in England on April 17, 1912, but of the instruments sent up one only was recovered, so that no comparison could be made.

On the average, the solar heat absorbed by the earth's surface and the atmosphere during one day is capable of raising the whole atmosphere about 1·5° C., and, of course, about the same amount must be lost per day by radiation. There is direct evidence that the daily change of temperature as we know it at the surface does not extend to more than 1 km. or 2 km., and from 2 km. to 20 km. the daily range can scarcely reach 1° C. In these circumstances the fall of temperature of the upper strata during an eclipse must be small, say $\frac{1}{4}°$ or $\frac{1}{2}°$ at the outside.

Our direct observations of atmospheric temperature very seldom exceed 20 km., and above that height we know neither the value nor the changes to which it is subject. This is perhaps of little consequence since at 20 km. more than 94 per cent. of the whole mass has been passed.

It must also be remembered that the line of lowest temperature will not be the axis of the shadow-cone, but will lag considerably behind it.

W. H. DINES.

Benson Observatory, Wallingford.

THE correction to the Einstein effect indicated by Mr. W. H. Dines's estimate of the depression of temperature in the eclipse shadow is even less than 10^{-11} radians or 10^{-6} seconds of arc. For a vertical ray the deflection caused by a horizontal temperature-gradient of $d\theta°$ C. in dx cm. is approximately

$$(\mu - 1)_G \,.\, H \,.\, \frac{d \log_e \theta}{dx},$$

where $(\mu - 1)_G = 28 \times 10^{-5}$ is the refractivity of air at normal density, and H is the height of the homogeneous atmosphere. For two rays at a mean distance in the atmosphere of a kilometre apart—a liberal estimate—the difference in deflection would be in c.g.s. units

$$28 \times 10^{-5} \times H \times 10^5 \,.\, d^2 \log \theta / dx^2.$$

If the shadow may be considered to have a radius of 500 km., then $d^2 \log \theta / dx^2$ would be of the order of 10^{-18}. From this the initial statement follows.

That is, assuming $\partial H / \partial x = 0$. But more simply conveniently, and accurately the bending of a vertical ray can be expressed in terms of the surface pressure-gradient because the refractivity is simply proportional to the density. So that five barometers, one at the eclipse station and four distributed around it, would yield the corrections for a single ray. The bending

© 1919 Nature Publishing Group